Some Measurements with a Simple Soil Penetrometer

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A simple penetrometer was used in order to obtain field data of some soil characteristics; two types of probes, for light and heavy soils, are available and the spring can be adjusted according to soil resistance. Results showed that, in certain cases, the penetrometer seems to be a useful device in giving a quantitative comparison of the differences between some soil characteristics.

1. The instrument

Inside the framework of the penetrometer (*Fig. 1*) there is a spring (A) set to work from 5 to 55 kg, as the probe is forced into the soil by hand at a uniform speed. The spring can be easily adjusted according to soil resistance or replaced by another spring. A reading is given in the upper part of the framework by an indicator (B) which is returned to a starting position by hand. The indicator is moved across the scale by the force of the inside stem (C) and is retained in its position by a small spring surrounding the small stem of the indicator. Two probes were constructed to work with this penetrometer, both 20 cm in length; one (a) with a cross-section of 1 cm square suitable for light soils, the other (b) pointed for heavier soils. The mark of 10 cm from the point is for the case of testing small samples under laboratory conditions.

2. Some soil tests

This penetrometer was used in an experiment under field conditions in order to show the effect of a synthetic soil conditioner on the structure of a non-saline alkali soil[1] (Table I). In this case probe (a) was used. The structure of this soil was greatly affected by the soil conditioner (*Fig. 2*): the decrease in resistance to the penetrometer was significant for the 1% level. In this test the penetrometer was very useful, giving a numerical expression of the influence of soil conditioners on soil aggregation.

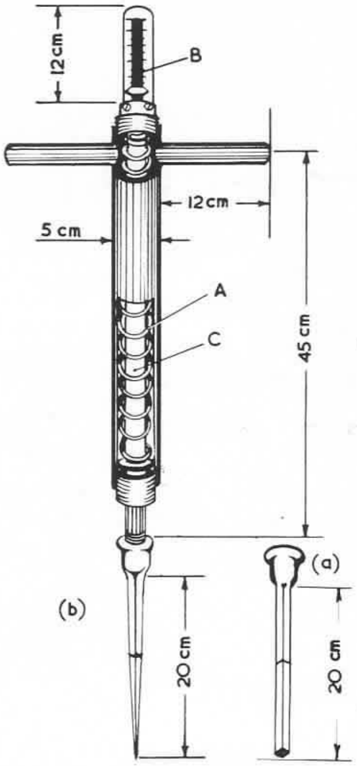

Fig. 1. The penetrometer

A clay loam soil, free from stones, was left uncultivated for about six months. In this area two tests were made (during November and April) at a time when ploughs and other implements were able to work easily. The purpose of these tests was to see if there is any correlation between soil resistance and the moisture con-

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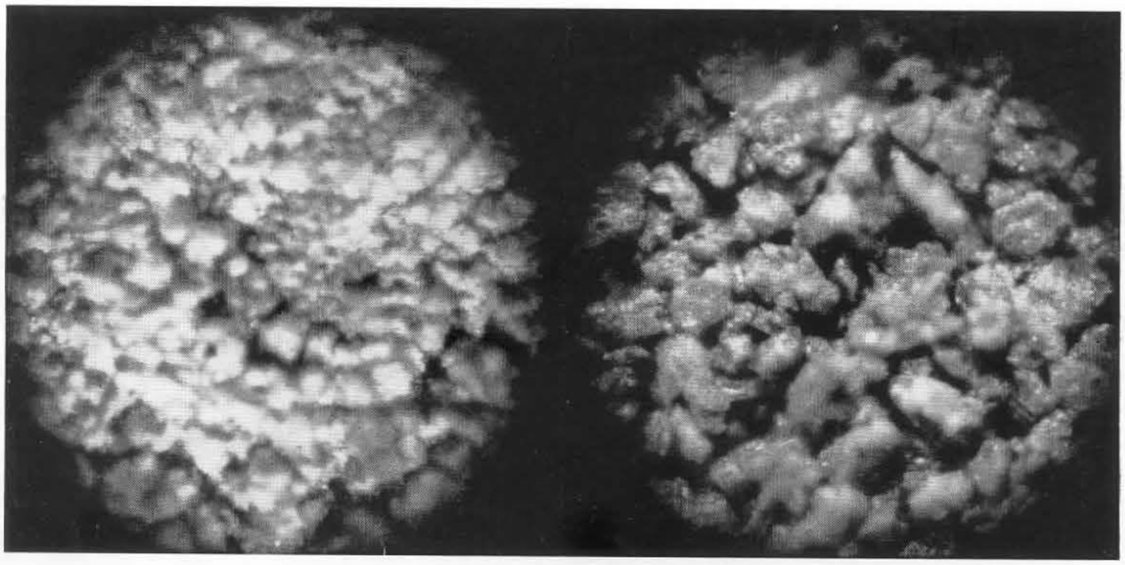

Fig. 2. Microphotograph of untreated soil (left) and soil treated with conditioner at 1500 kg/ha (Magnification × 112)

tent and mechanical structure of the soil. Probe (b) was used. The soil resistance values in Tables II and III are the averages of six measurements in a small circle (15 cm dia). Soil samples were taken in each case from a depth 10–20 cm. Moisture content of the samples was determined by drying at 105 °C for 24 h. For mechanical analysis the pipette method[2] was used. Another test was conducted during November in a sandy loam soil (Table IV) for the same purpose and under the same experimental conditions. Additionally the soil permeability in cm^3 water per 15 min was estimated by Kuron's system.[*] From Tables II–IV it is obvious that in no case was soil resistance correlated to any of the studied soil characteristics in the last three tests; it was slightly influenced by moisture content (*Fig. 3*, left). In Test 4 the correlation coefficient of soil resistance and moisture content was only − 0·0173. Colloidal fraction and sand did not influence the soil resistance in Tests 2 and 3 and in Test 4 colloidal fraction showed a slight influence on soil resistance (*Fig. 3*, right) but in an unexpected way ($r = -0{\cdot}2313$). Soil permeability also showed little correlation to soil resistance ($r = 0{\cdot}22$) and the probability that these factors were correlated was only 55 %.

TABLE I

Soil resistance in a non-saline alkali soil treated by soil conditioner (Test 1)

Conditioner, kg/ha	*Soil resistance, kg*					*Total*	*A. mean*
—	13·5	13·5	12·0	12·5	15·0	66·5	13·3
900	8·5	11·0	10·5	14·0	12·0	56·0	11·2
1500	7·0	7·5	9·5	7·5	7·5	39·0	7·8
Total	29·0	32·0	32·0	34·0	34·5	161·5	

L.S.D. for $P_{0{\cdot}05} = \pm\, 2{\cdot}18$; for $P_{00{\cdot}1} = \pm\, 3{\cdot}18$

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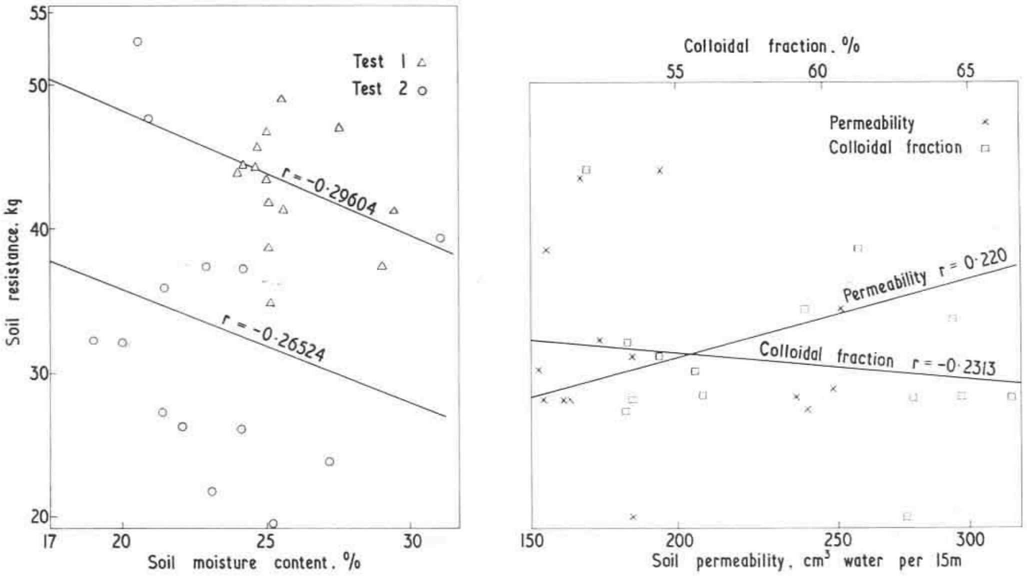

Fig. 3. Correlations

TABLE II

Soil resistance and analysis
(Clay loam, Test 2)

Soil resistance, kg	*M.c., %*	*Clay, %*	*Silt, %*	*Sand, %*	
		<0·002 mm	*0·02–0·002 mm*	*2–0·2 mm*	*0·2–0·02 mm*
49·0	25·5	51·6	35·8	3·4	9·2
47·0	26·5	50·0	35·6	3·1	11·3
46·8	25·0	53·5	34·1	3·0	9·4
45·5	24·7	46·8	31·4	4·9	16·9
44·3	24·3	36·5	44·0	3·4	18·1
44·2	25·7	50·0	23·6	5·4	21·0
44·0	24·4	49·2	27·7	3·4	18·7
43·3	25·0	50·0	34·4	3·2	12·4
41·8	25·1	43·5	39·2	4·4	12·9
41·2	29·4	55·5	24·0	3·2	17·3
41·1	25·6	34·0	43·7	2·2	21·1
41·1	—	47·7	31·7	4·1	16·5
38·7	25·1	51·0	35·8	3·6	9·6
37·4	29·0	50·4	36·7	4·3	8·6
34·7	25·2	50·0	31·0	4·1	14·9

TABLE III

Soil resistance and analysis
(Clay loam, Test 3)

Soil resistance, *kg*	*M.c.,* %	*Colloidal fraction,* %	*Sand,* %
55·0	18·0	75·5	24·5
53·0	20·6	73·6	26·4
47·8	21·4	69·0	31·0
41·3	30·9	68·5	31·5
38·1	24·3	70·3	29·7
37·3	22·8	71·0	29·0
36·0	21·5	76·0	24·0
32·1	19·0	69·0	31·0
32·0	20·0	68·3	31·7
27·3	21·4	65·0	35·0
26·1	22·3	68·2	31·8
26·0	24·2	72·8	26·8
23·8	27·3	73·6	26·4
21·8	23·1	73·0	27·0
20·3	19·8	69·4	30·6
19·3	25·2	77·5	22·5

3. Discussion

Local heterogeneity of the soil, the presence of organic matter, distribution of plant roots, soil texture, and soil aggregation seem to be factors that affect soil resistance to the probe to a greater or lesser extent. Moreover, moisture content and soil compaction complicate the whole problem and the process of penetration is mechanically complicated.[3] In saturated soils little force is recorded even on compacted soil and under dry conditions the soil may be so hard that the probe cannot be made to enter. Penetrometers can thus be used only at soil moisture contents of 15–25%. Soil compaction caused by tractors, and other machinery seems to have some serious effect on soil resistance. Free[4] pointed out that a compact layer of soil below plough depth could be created by traffic. Pressure stress can reach a depth of 60 cm and pressure distribution depends on tractor load, on the wheel size and on the inflation pressure of the wheels.[5]

The conclusion is that the soil penetrometer is useful to investigators in order to express the change of a given soil characteristic, if the others

TABLE IV

Soil resistance and analysis
(Sandy loam, Test 4)

Soil resistance, *kg*	*M.c.,* %	*Clay,* %	*Silt,* %	*Sand,* %		*Permeability,* *cm^3 water per 15 min*
				Coarse	*Fine*	
44·0	17·8	5·4	50·6	3·4	40·6	194·5
43·4	18·2	—	—	—	—	165·5
38·4	19·6	3·4	57·9	3·5	35·2	156·0
34·2	18·3	3·3	56·1	4·4	37·2	256·5
33·5	19·5	2·7	61·8	3·1	32·4	—
32·0	16·4	9·2	44·1	8·4	38·3	174·5
31·0	11·3	3·9	50·5	9·0	36·6	185·0
30·0	13·0	3·4	52·2	8·5	35·9	152·5
28·2	18·3	6·2	49·6	7·0	37·2	249·0
28·0	19·4	2·7	62·1	3·0	32·2	162·0
28·0	18·6	3·0	60·2	3·1	33·7	154·0
28·0	20·2	2·9	63·6	3·0	40·5	186·5
28·0	19·5	3·6	49·9	11·0	35·5	162·5
27·2	16·5	10·9	43·4	7·2	38·5	189·0
19·6	18·9	2·8	59·6	2·7	34·9	174·5

remain about constant, by arbitrary comparative numbers. In this respect, the present type of penetrometer seems to be better than the hammer type since it is direct indicating and no calculations are needed to interpret soil resistance in kg. Penetrometers also seem to be useful for soil compaction studies in areas with no traffic sole. Since soil resistance is affected by more than one soil characteristic at the same time, it is very difficult to evaluate the importance of each one of these characteristics. Consequently, the penetrometer does not seem to be a practical device for the farmer.

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